

CPE/EE 322
Engineering Design VI
Lesson 10: Design Analysis

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2023-04-10

Outline

1. Evaluating alternative designs
2. Rank-ordering the design goals
3. Assigning weighting factors to design goals
4. Rating the alternative designs
5. Decision matrix
6. Kepner-Tregoe (KT) decision and potential problem analysis
7. Value and subjectivity of a decision matrix
8. Economic analysis

Objectives

[G. Voland, Engineering by Design, Chapter 10](#)

- Apply design evaluation via tools such as decision matrices and the Kepner-Tregoe (KT) analysis method to
 - Prioritize design goals
 - Rank each design alternative in terms of its ability to achieve the desired goals
 - Determine the best solution to the problem
 - Identify the relative strengths and weaknesses (including potential hazards) of the best design
- Maintain the highest level of critical objectivity when developing a decision matrix to avoid misleading or incorrect results due to subjectivity
- Recognize the importance of the time value of money and identify many of the factors that can affect the final cost of a design

Lab 10 – Blockchain

- Study the GitHub [repository](#) Lesson 10
- Run hash_value.py twice and compare results
- Run snakecoin.py
- Run snakecoin-server-full-code.py on Terminal 1 and mine a new block on Terminal 2
- Clone Python blockchain app and uncomment the last line of node_server.py
- Run node_server.py on Terminal 1 and run_app.py on Terminal 2

Assignment 10 — Design Analysis

Revisit the morphological chart in Assignment 7 (Synthesis) and

- Develop a KT decision matrix for design alternatives and goals with weighting, rating, and decision factors
- Develop a KT evaluation matrix for design alternatives and adverse consequences with probability, severity, and threat

Program Outcome 2: (Design)

2.2 (Technical design) Students will be able to explore the design space of performance, features, and cost to determine the cost (fixed and operating) of a given project "product."

Evaluating Alternative Designs

- [Steve Jobs](#) 1955—2011, "Most people make the mistake of thinking design is what it looks like. That's not what we think design is. It's not just what it looks like and feels like. Design is how it works." — [Leander Kahney](#), "[Straight Dope on the iPod's Birth](#)," [Wired](#), 2006-10-17
- Prioritize or weight the design goals against which each alternative will be evaluated
- Formulate a scheme by which ratings can be assigned to each design concept
- Combine the prioritized weightings of the goals with the ratings given to the designs to generate a combined score for each of the alternative solutions
- Compare the total scores of all design alternatives to identify the best solution
- Carefully re-evaluate the best solution to determine if any remaining weaknesses in the design can be either minimized or eliminated, and to anticipate any hazards that may be associated with its implementation, i.e., refine the final design selection as appropriate

Rank-Ordering Design Goals

A column goal is more (1), equal (0.5), or less (0) important than a row goal

Goals	Performance	Minimum maintenance	Aesthetics	Cost	Availability of parts	Ease of use	Versatility	Portability
Performance	—	0	0	0.5	0	0	1	1
Minimum maintenance	1	—	0	1	1	1	1	1
Aesthetics	1	1	—	1	1	1	1	1
Cost	0.5	0	0	—	0	0	1	1
Availability of parts	1	0	0	1	—	1	1	1
Ease of use	1	0	0	1	0	—	1	1
Versatility	0	0	0	0	0	0	—	0
Portability	0	0	0	0	0	0	1	—
Total score	4.5	1	0	4.5	2	3	7	6

Assigning Weighting Factors

Priority	Weighting Factor	Design Goal
Critical	100	Versatility
	90	Portability
	80	
Important	70	Performance, cost
	60	
	50	Ease of use
	40	
	30	Availability of parts
Optional	20	Minimum maintenance
	10	<u>Aesthetics</u>
	0	

Rating Alternative Designs

- If possible, use measurable parameters to estimate the success or failure of each design in achieving a particular goal
- For those goals that can not be converted into a truly quantifiable form, an arbitrary rating scale can be used

Excellent	10
Good	8
Satisfactory	6
Mediocre	4
Unacceptable	2
Failure	0

Decision Matrix

Goals	Weighting factors (W)	Rating factors (R)			
		Alternative 1	Alternative 2	Alternative 3	Alternative 4
Versatility	100	7	4	6	9
Portability	90	6	3	7	6
Performance	70	8	6	9	7
Cost	70	7	6	8	3
Ease of use	50	7	7	4	6
Availability of parts	30	9	8	6	6
Minimum maintenance	20	6	9	4	2
Aesthetics	10	9	4	5	8
Decision factors ($D = W \times R$)		3120	2320	2930	2740

KT Decision Matrix

Decision factor (D) = Weighting factor (W) \times Rating factor (R)

Needs		Alternatives allowing passengers on a ship or airplane to escape unharmed							
		<u>Flotation device</u>		<u>Lifebelts</u>		<u>Escape pods</u>		Converta-Craft	
Provide life support		Go		Go		Go		Go	
Economically feasible		Go		Go		No go		Go	
Wants	W	R	$D = W \times R$	R	$D = W \times R$	R	$D = W \times R$	R	$D = W \times R$
Compact	5	9	45	2	10	—	—	5	25
Environmentally safe	9	2	18	8	72	—	—	8	72
Reusable	7	3	21	9	63	—	—	9	63
Other	3	3	9	2	6	—	—	5	15
Total			93		151		—		175

KT Evaluation Matrix

Threat (T) = Probability (P) \times Severity (S)

Adverse consequences	Probability (P)	Severity (S)	Threat ($T = P \times S$)
Flotation device			1.85
May fail because of leakage	0.05	9	0.45
May not be activated properly	0.10	5	0.50
Passengers may crowd onto a single unit	0.10	9	0.90
Lifebelts			1.15
May be misused by passengers	0.10	7	0.70
May be lost or misplaced	0.05	9	0.45
Converta-Craft			2.15
Unreliable under certain conditions	0.10	8	0.80
There may be insufficient time to activate device	0.15	9	1.35

Value and Subjectivity

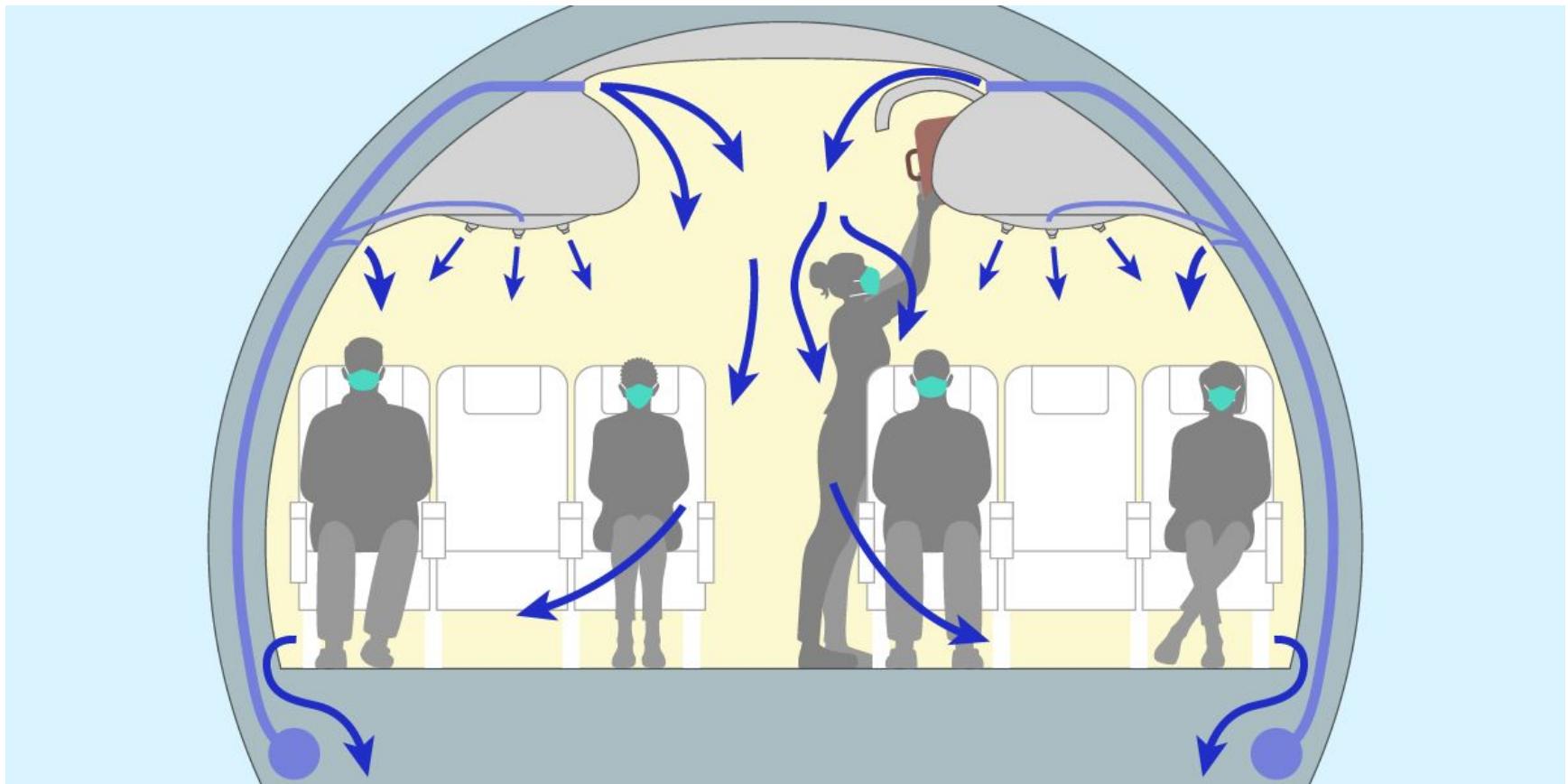
- The value of a decision matrix
 - View the various design alternatives in a careful and thoughtful manner
 - Prioritize the the goals to be achieved by a solution
 - Revisit or revise the original formulation of the problem
 - Consider the relative strengths and weaknesses
- On the other hand, the results can be misleading or even skewed to support one's initial intuitive choice if one fails to maintain the highest level of critical objectivity

Buridan's Ass

- [Buridan's ass](#), named after [Jean Buridan](#) c. 1301 — c. 1359/1362, refers to a hypothetical situation wherein an ass (donkey) that is equally hungry and thirsty is placed precisely midway between a stack of hay and a pail of water
- Since the [paradox](#) assumes the ass will always go to whichever is closer, it dies of both hunger and thirst since it cannot make any rational decision between the hay and water
- A [dilemma](#) (or poylemma) is a problem involving a difficult choice of two (or more) alternatives
- [Coin flipping](#) (coin tossing, obverse or reverse, or heads or tails) is the practice of throwing a coin in the air and checking which side is showing when it lands to choose between two alternatives, e.g., [Coin Flipper](#), [Just Flip A Coin](#), etc.
- In the theory of probability and statistics, a [Bernoulli trial](#) (or binomial trial) named after Swiss mathematician [Jacob Bernoulli](#) 1655—1705, is a random experiment with exactly two possible outcomes, "success" and "failure," in which the probability of either is the same every time the experiment is conducted

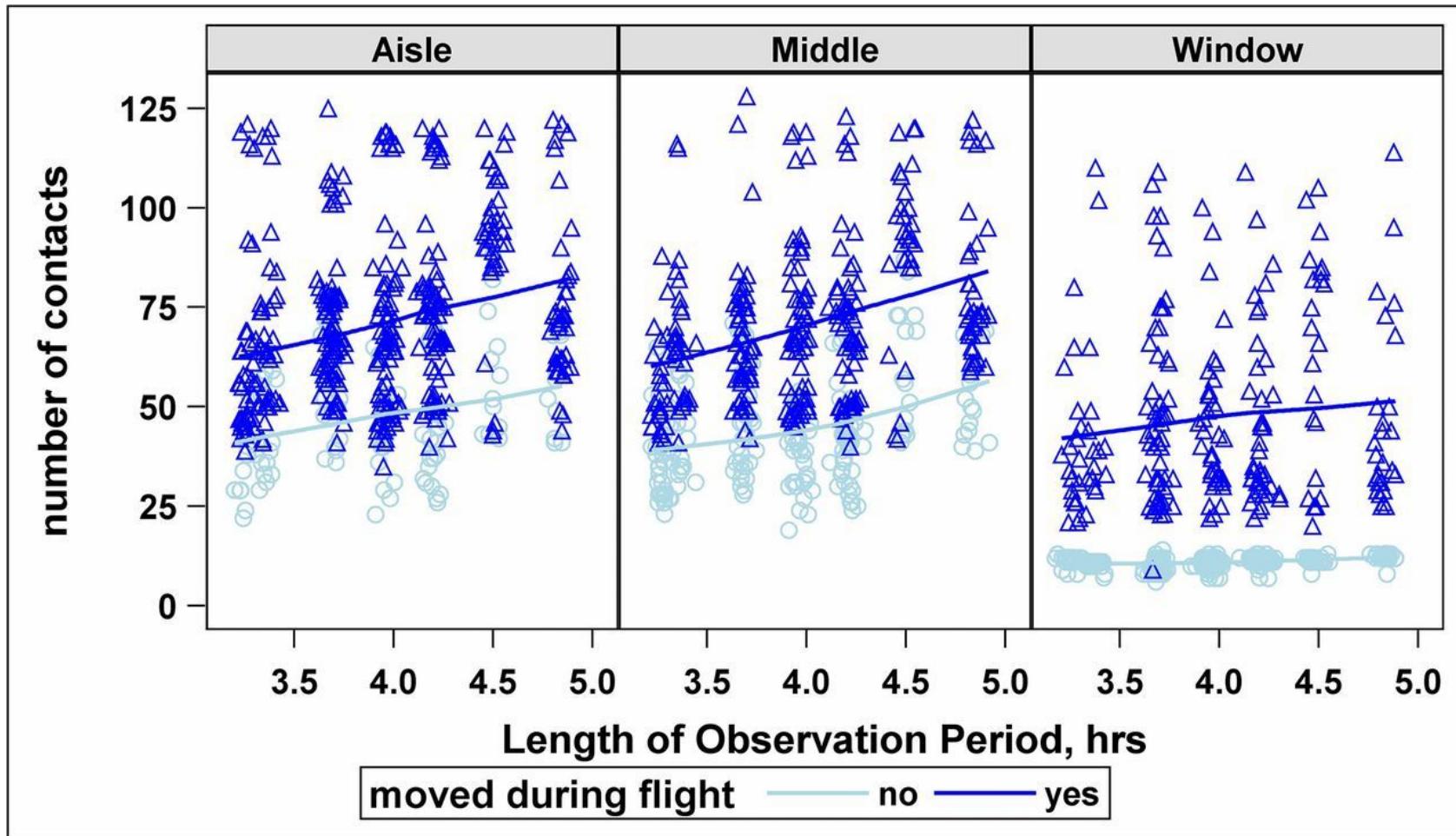
Aisle or Window?

How safe is air travel? High-efficiency particulate air ([HEPA](#)) filter



Risk of Infectious Diseases

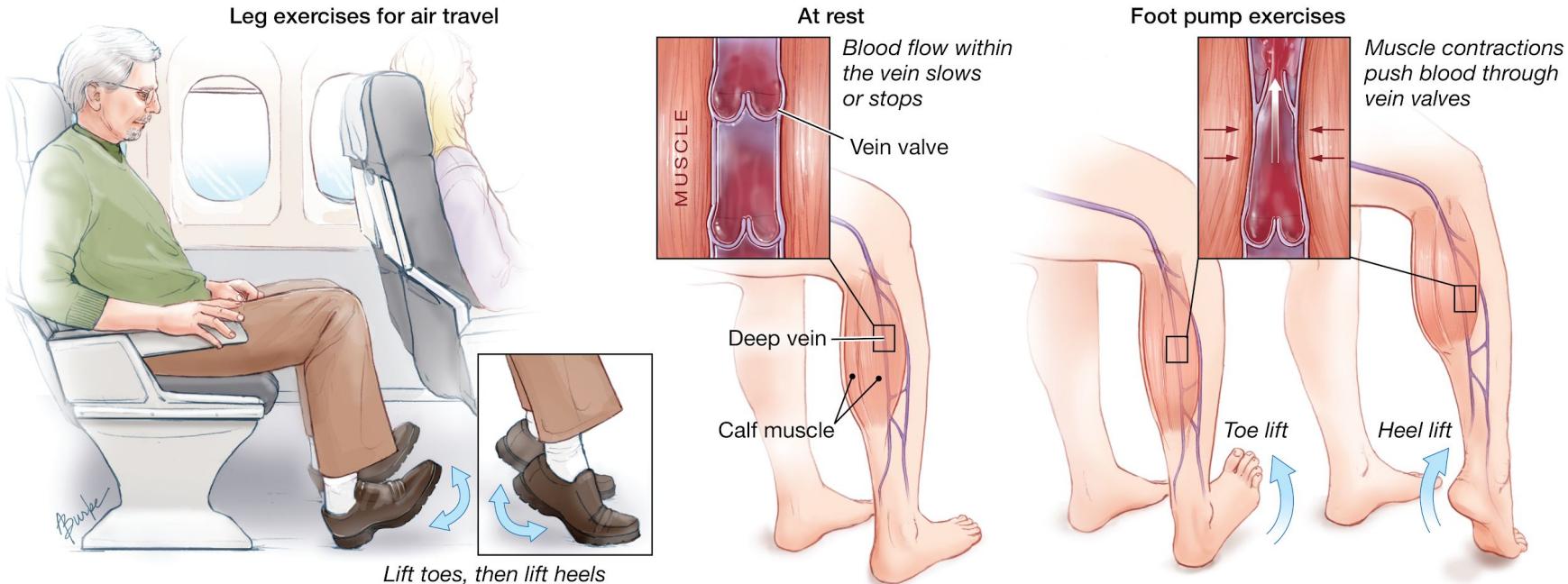
Behaviors, movements, and transmission of droplet-mediated respiratory diseases
during transcontinental airline flights



Risk of Blood Clots

<https://jamanetwork.com/journals/jama/fullarticle/1486833>

- Sitting still for extended periods of time can affect blood circulation and lead to the development of blood clots
- Airplane flights of four hours or more may be a risk factor for deep vein thrombosis (DVT) and pulmonary embolism (PE)



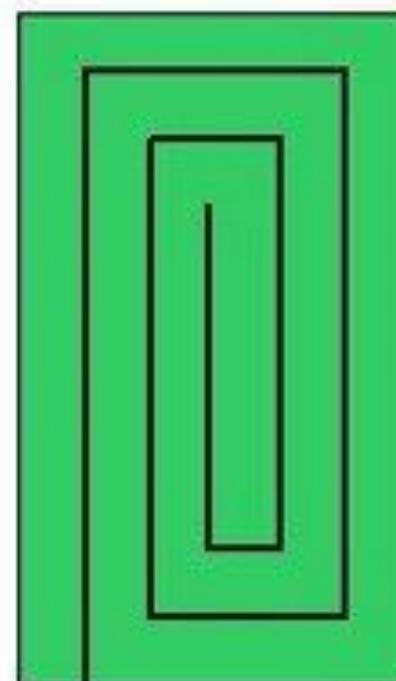
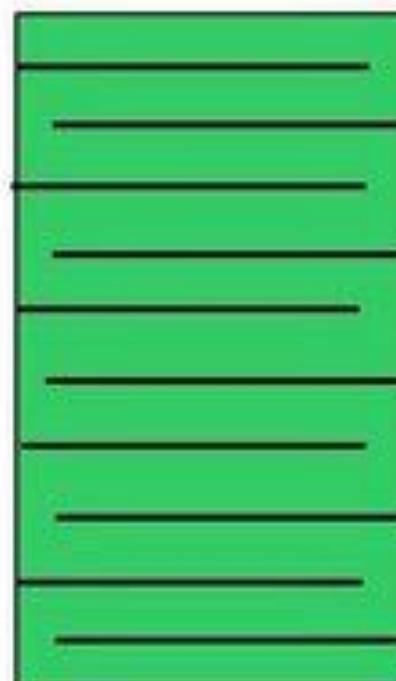
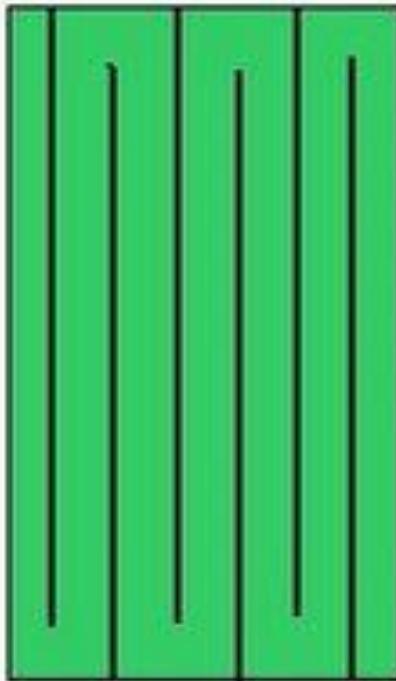
Explainable AI (XAI)

- Explainable AI (XAI) refers to methods and techniques in the application of artificial intelligence technology such that the results of the solution can be understood by human experts
- It contrasts with the concept of the "black box" in machine learning where even their designers cannot explain why the AI arrived at a specific decision
- XAI is an implementation of the social right to explanation
- Some claim that transparency rarely comes for free and that there are often trade-offs between the accuracy and the explainability of a solution
- The technical challenge of explaining AI decisions is sometimes known as the interpretability problem
- Another consideration is information overload when full transparency may not be always possible or even required
- AI systems optimize behavior to satisfy a mathematically specified goal system chosen by the system designers
- A human can audit rules in an XAI to get an idea how likely the system is to generalize to future real-world data outside the test-set

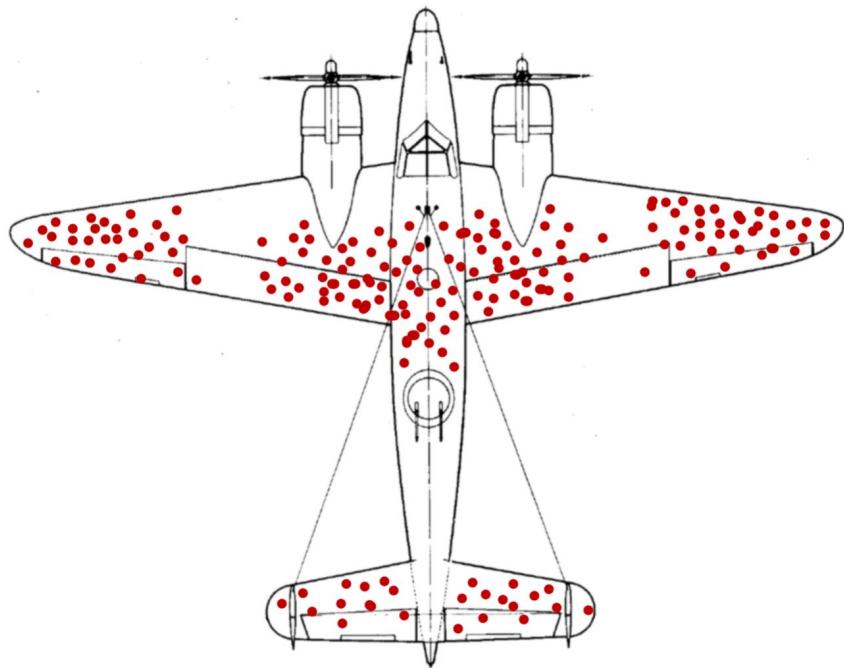
Aesthetic Mowing Patterns

<http://blog.themathmom.com/2009/07/math-of-lawn-mowing.html>

The vertical parallel or horizontal parallel with 180° turns, or the concentric pattern with mostly 90° turns?

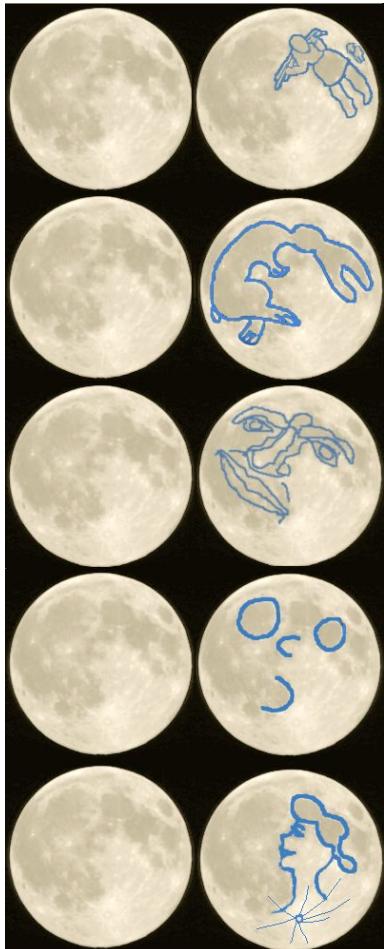


Selection Bias



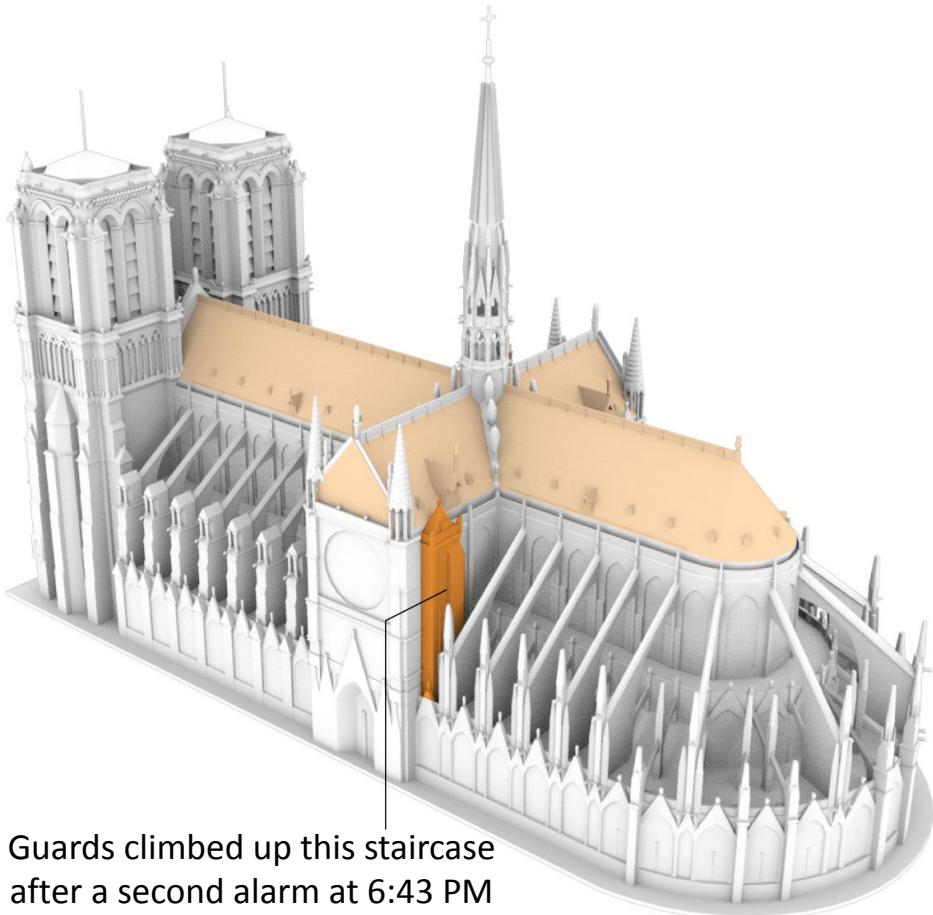
- The damaged portions of returning planes show locations where they can sustain damage and still return home
- Bias is disproportionate weight in favor of or against an idea or thing
- Abraham Wald 1902—1950 proposed to reinforce areas where the returning aircraft were unscathed as opposed to damaged due to survivorship bias
- Selection bias is the bias introduced by the selection of individuals, groups or data for analysis in such a way that proper randomization is not achieved
- Statistical bias results from an unfair sampling of a population, or from an estimation process that does not give accurate results on average

Heuristics and Cognitive Biases



- A [heuristic](#) is any approach to problem solving or self-discovery by employing a practical method that is not guaranteed to be optimal, perfect, or rational, but is sufficient for reaching an immediate, short-term goal
- A [cognitive bias](#) is a systematic pattern of deviation from norm or rationality in judgment [[list of cognitive biases](#)]
- [Karl Ludwig Kahlbaum](#) 1828—1899 used [pareidolia](#) to describe the tendency for incorrect perception of a stimulus as an object, pattern, or meaning known to the observer, e.g., interpretations of the random crater patterns on the Moon
- [Klaus Conrad](#) 1905—1961 used [apophenia](#) to describe the tendency to mistakenly perceive connections and meaning between unrelated things
- On the other hand, [Gerd Gigerenzer](#) argues that using heuristics and cognitive biases are rational and helpful for making decisions in our everyday life

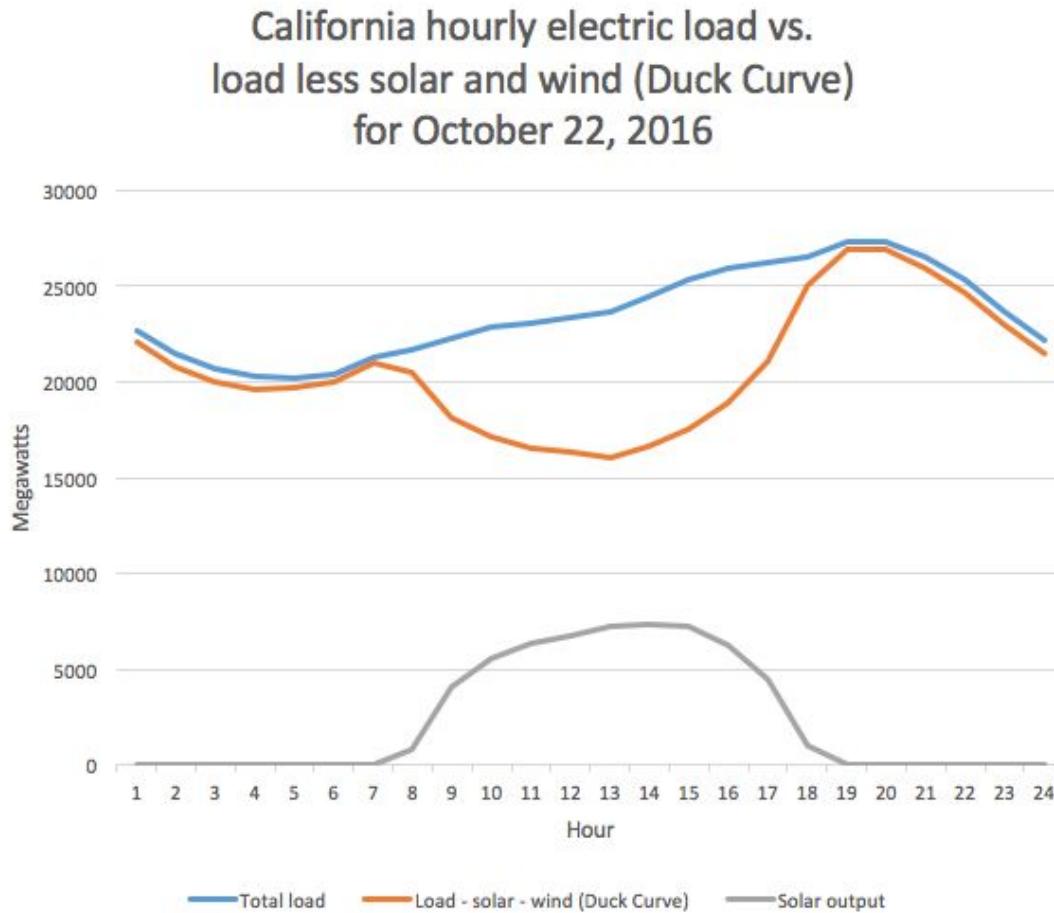
Response Time



- Unlike at sensitive sites in the United States, fire alarms in France never automatically alert the fire department
- Guards responding to a fire alarm at [Notre-Dame](#) on 2019-04-15 had to climb a steep set of stairs and check for a fire before they could notify the fire department
- The response to the [Notre-Dame fire](#) wasted 31 critical minutes between the first alarm at 6:20 PM and the call to the fire department at 6:51 PM

Duck Curve

https://en.wikipedia.org/wiki/Duck_curve



- The amount of power that must be generated from sources other than solar or wind displays a rapid increase around sunset and peaks in the mid-evening hours, resembling the silhouette of a duck
- The California Independent System Operator ([CAISO](#)) shows utility-scale batteries charging and discharging into the power grid via their [website](#)

Solar Power Tower

The [solar power tower](#) such as the [PS10](#) in Seville, Spain is a type of [solar furnace](#) using a tower to receive the [concentrated solar power](#) to store heat using water or [molten salts](#) (40% potassium nitrate, 60% sodium nitrate) and to power a steam turbine



Wind Turbines

- Most [wind turbines](#) have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator
- [Vertical-axis wind turbines](#) (VAWT) don't require a complex mechanism and motors to yaw the rotor and pitch the blades
- [Unconventional wind turbines](#) differ from the most common ones in rotor types, basic functionalities, supporting structures, and form-factors
- In urban spaces, tall buildings push wind in many directions at once
- The [O-Wind](#) is a small, spherical wind turbine to catch vertical, horizontal, and diagonal wind at the same time



Bitcoin Electricity Consumption

- Given that the exact electricity load and consumption of the [Bitcoin network](#) cannot be determined, the [Cambridge Bitcoin Electricity Consumption Index](#) (CBECI) provides a range of possibilities consisting of a lower bound and an upper bound estimates corresponding to
 - The absolute minimum total electricity expenditure based on the best case assumption that all miners always use the most energy-efficient equipment available on the market
 - The absolute maximum total electricity expenditure based on the worst case assumption that all miners always use the least energy-efficient equipment available on the market as long as running the equipment is still profitable in electricity terms
- Within the boundaries of this range, a best-guess estimate is calculated to provide a more realistic figure that comes closest to Bitcoin's real annual electricity consumption
- The best-guess estimate is based on the assumption that miners use a basket of profitable hardware rather than a single model

Aluminum Smelting

- Aluminum smelting is the process of extracting aluminum from aluminum oxide (commonly called alumina extracted from the ore bauxite) by the Hall-Héroult electrolytic process that uses huge amounts of electricity
- About eight percent of global electric power is lost in transmission and distribution
- Smelters tend to be located close to large power stations, often hydro-electric ones, where electricity is abundant, and where the local consumers may not be able to absorb all that capacity, e.g., Plattsburgh, New York
- Smelters are often located near ports, since many smelters use imported alumina
- This led to an Icelandic economist stating that Iceland exports energy in the form of aluminum, and hoping it can replicate this model to exports energy as data
- Smelters have been converted into Bitcoin mines, e.g., Coinmint operates a digital currency data center at a former Alcoa Aluminum smelter in Massena, New York

Natural Gas Flaring

- Routine flaring, also known as production flaring, is a method and current practice of disposing of large unwanted amounts of associated petroleum gas (APG) during crude oil extraction
- The gas is first separated from the liquids and solids downstream of the wellhead, then released into a flare stack and combusted into earth's atmosphere (usually in an open diffusion flame)
- Where performed, the unwanted gas (mostly natural gas dominated by methane) has been deemed unprofitable, and may be referred to as stranded gas, flare gas, or simply as "waste gas"
- Routine flaring is not to be confused with safety flaring, maintenance flaring, or other flaring practices characterized by shorter durations or smaller volumes of gas disposal
- Instead of wasting the excess natural gas, companies (e.g., Crusoe Energy Systems) convert it to electricity, and transfers the power to servers at the data center on the well site for computing tasks such as Bitcoin mining
- Using satellite internet, these companies digitally transfer the output product

SWOT Analysis



- SWOT analysis is a strategic planning technique used to help a person or organization identify strengths, weaknesses, opportunities, and threats related to business competition or project planning
- The alternatives to SWOT include SVOR (Strengths, Vulnerabilities, Opportunities, and Risks) and Five Forces Analysis of threat of new entrants and substitutes, bargaining powers of customers and suppliers, and competitive rivalry, created by Michael Porter of Harvard Business School

Economic Analysis

- Cost estimation
 - Capital expenditure (CAPEX)
 - Engineering, furnishing, and installation (EF&I)
 - Operational expenditure (OPEX)
 - Operations, Administration, and Management (OA&M)
- Return on investment (ROI) is net income divided by investment
- The notion of the time value of money dates back at least to Martín de Azpilcueta 1491–1586 of the School of Salamanca

PV is the present value
FV is the future value
n is the number of periods
i is the interest rate at which the amount compounds each period

$$PV = \frac{FV}{(1+i)^n}$$

Zero-Based Budgeting (ZBB)

- Pete Pyhrr developed zero-based budgeting in 1969 at Texas Instruments
- Zero-based budgeting starts from a "zero base"
- Every function within an organization is analyzed for its needs and costs
- Budgets are then built around what is needed for the upcoming period regardless of whether the budget is higher or lower than the previous one
- That is, all expenses must be justified for each new period
- Further readings:
 - Chapter 8 on work breakdown structure (pp. 65 to 78) of the U.S. Government Accountability Office (GAO) [Cost Estimating and Assessment Guide](#)
 - GAO Cost and Schedule Assessment Guides [[PDF](#)]

Bill of Materials (BOM)

- A bill of materials (BOM) is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts, and the quantities of each needed to manufacture an end product
- A BOM may be used for communication between manufacturing partners or confined to a single manufacturing plant
- Often tied to a production order, a BOM may generate
 - Reservations for components that are in stock
 - Requisitions for components that are not in stock

MRO

- Maintenance, repair, and operations (MRO) items are supplies consumed in the production process that do not become part of the end product or are not central to the output
 - Consumables such as cleaning, laboratory, or office supplies
 - Industrial equipment such as compressors, pumps, and valves
 - Plant upkeep supplies such as gaskets, lubricants, and repair tools
 - Computers
 - Fixtures
 - Furniture

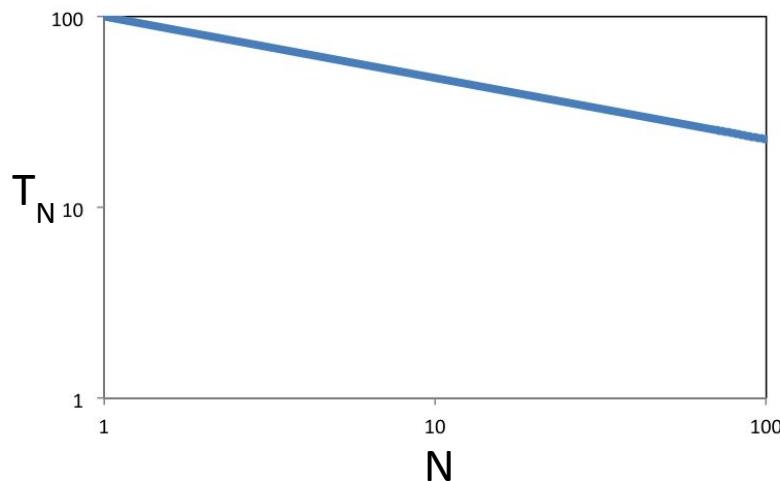
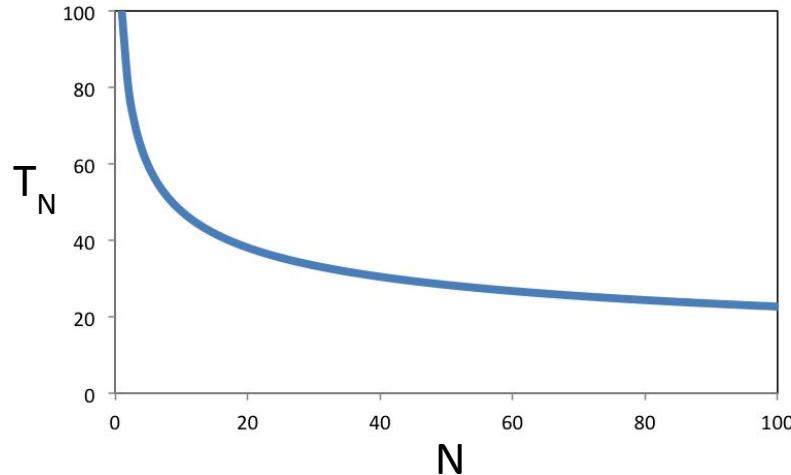
Direct and Indirect Costs

- Direct costs can be traced to or identified with any particular product, material, and labor for engineering, furnishing, and installation (EFI)
- Indirect costs are overhead expenses for operations, administration, and maintenance (OAM) that cannot be traced to or identified with any particular product or material
 - Accounting and interest
 - Advertising
 - Insurance
 - Legal
 - Labor burden
 - Rent
 - Taxes
 - Travel expenditures
 - Utilities

Economies of Scale and Scope

- Economies of scale: reductions in the average cost from increasing the *scale* of service for a *single* product type
- Economies of scope: reductions in the average cost from increasing the *scope* of service for *multiple* product types

Learning Curve (1936)

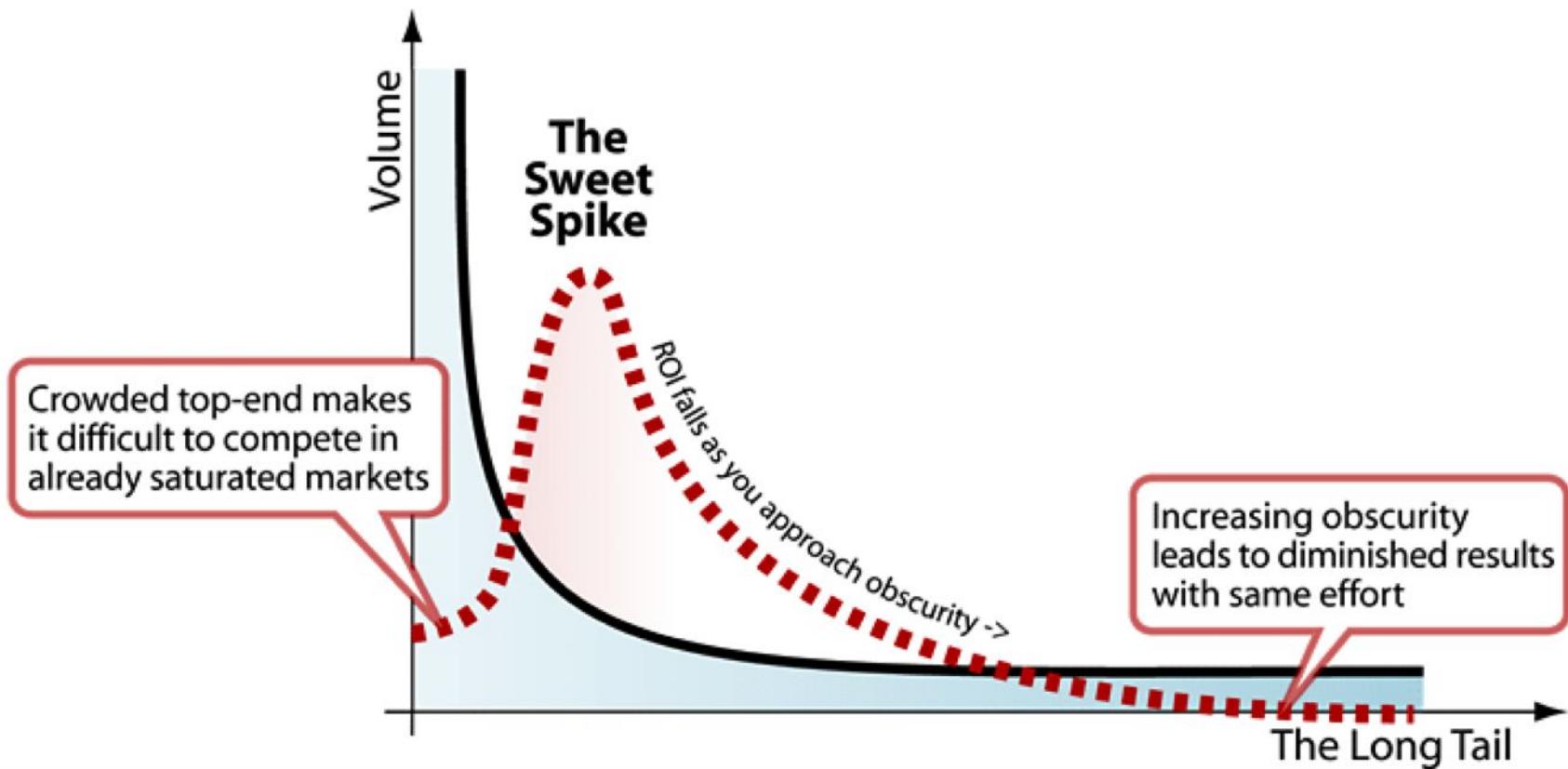


[Theodore Paul Wright](#) 1895–1970

Time (or cost) per N repetitions $T_N = T_1 N^b$,
 $b = \log_2 a$, a = learning rate, e.g., 0.8

Long Tail and Return on Investment

https://en.wikipedia.org/wiki/Long_tail



Contract Types

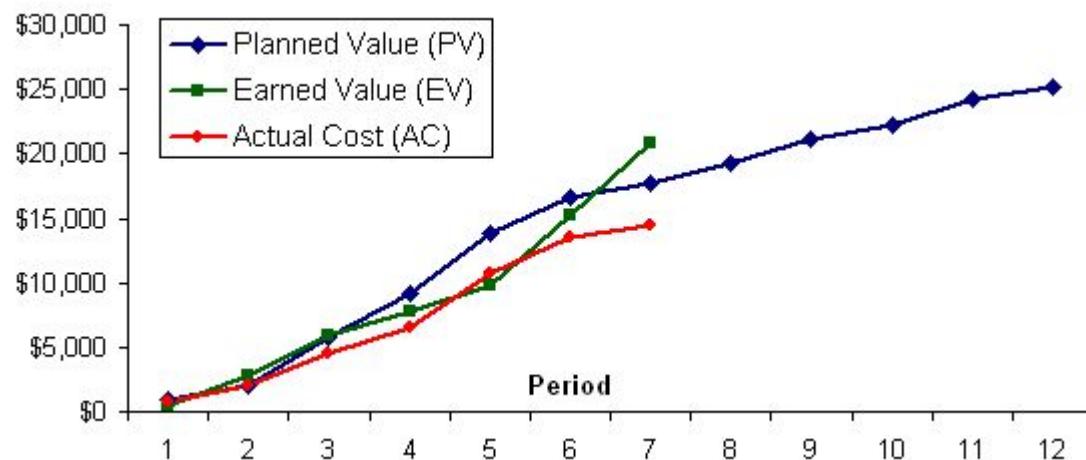
<https://en.wikipedia.org/wiki/Contract>

- Fixed-price contract
 - Clearly defined scope and schedule
 - Can include incentives or benefits for early completion, and penalties for late completion
- Cost-plus contract
 - Scope has not been clearly defined
 - Specific material and direct labor cost plus a pre-negotiated percentage covering contractor's overhead and profit
 - The owner must establish limits on billing
- Time and materials
 - Scope has not been clearly defined
 - The owner and the contractor must establish an agreed hourly or daily rate, including additional expenses
- Unit price
 - The owner requests specific quantities and pricing for a predetermined amount of unitized items

Earned Value Management (EVM)

EVM is a project management technique for measuring project performance and progress by combining measurements of scope, time, and costs including

- A project plan that identifies work to be accomplished
- A valuation of planned work, called Planned Value (PV) or Budgeted Cost of Work Scheduled (BCWS)
- Predefined "earning rules" (also called metrics) to quantify the accomplishment of work, called Earned Value (EV) or Budgeted Cost of Work Performed (BCWP)



Transparency and Traceability

<https://www.transparency-one.com/transparency-vs-traceability-whats-the-difference>

- Transparency refers to the capture and transference of high-level information along the supply chain that is specific and accurate, relating to the components of a product, the names of suppliers, the location of facilities, associated certificates, etc.
- The information captured during traceability is more granular, relating to individual ingredients or components such as batch-lot data (catch/harvest date, field data, etc.), purchase order (PO) data, and other operational information
- Whereas transparency focuses on mapping the whole supply chain, traceability looks at individual batches of components or purchase orders as they progress through the supply chain

Lesson 10 Summary

- Design evaluation via tools such as decision matrices and the Kepner-Tregoe analysis method can
 - Prioritize design goals
 - Rank each design alternative in terms of its ability to achieve the desired goals
 - Determine the best solution to the problem
 - Identify the relative strengths and weaknesses including potential hazards of the best design
- Perform Kepner-Tregoe potential problem analysis to compare and contrast the specific risks associated with each of the proposed solutions
- Maintain the highest level of critical objectivity when developing a decision matrix to avoid misleading or incorrect results due to subjectivity
- Carefully estimate costs associated with the design and development of any new device, system, or process

Justitia and Prudentia

Two allegories of the four cardinal virtues

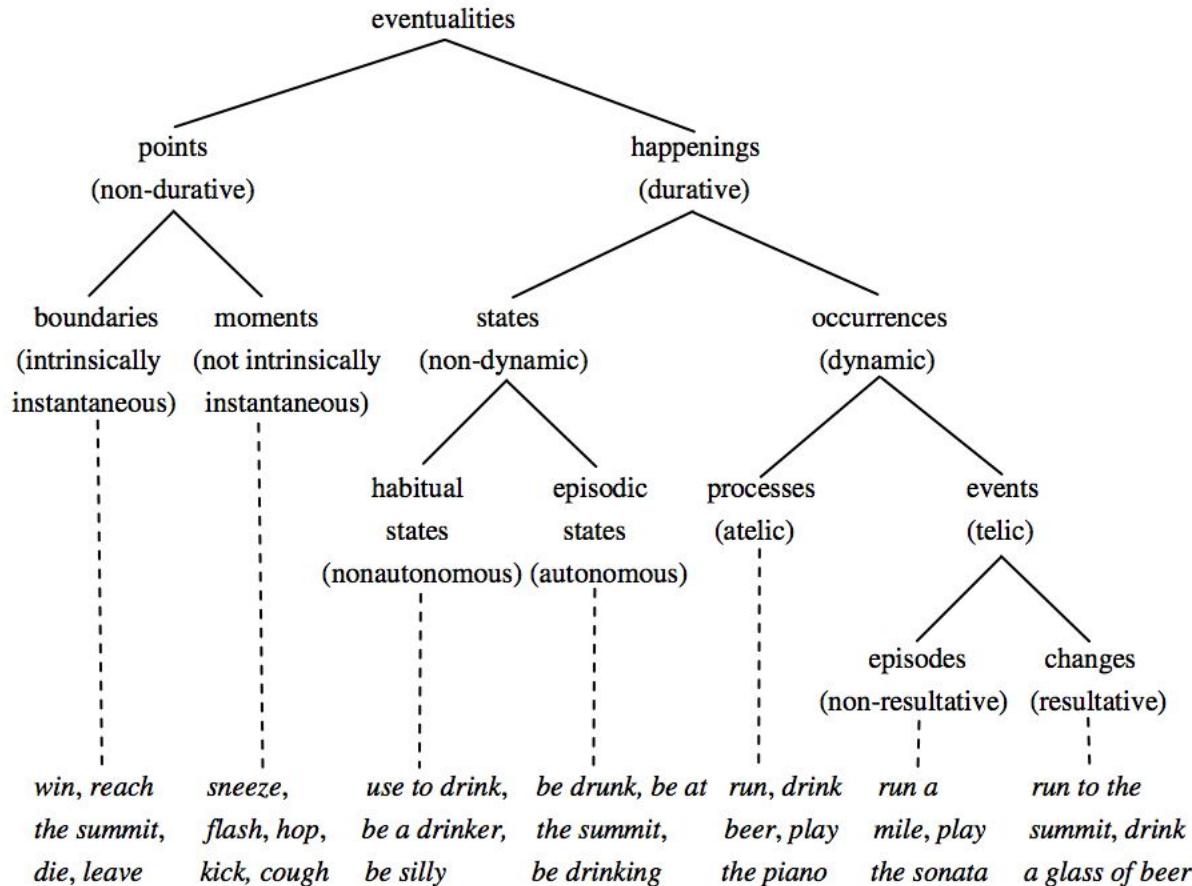
- Justitia (justice) holds a sword (power) and a balance (fairness) representing the resolution from weighing the evidence for support and opposition
- Prudentia (prudence) holds a mirror (conscience) and a snake (wisdom) representing the ability to judge between actions with regard to appropriate actions at a given time

The other two cardinal virtues are courage (or fortitude) and temperance



Eventuality Structure

[Johannes Dölling](#), University of Leipzig



Telicity of a verb or verb phrase presents an action or event as being complete

Left Hand or Right Hand?

- Human [handedness](#) (cf., [hair whorl](#) orientation on the head) is a better, faster, or more precise performance or individual preference for use of a hand
- About 90% of the world's population is right-handed [[Source](#)]
- A [southpaw](#) is a left-handed person, especially a boxer or baseball pitcher
- [Ambidextrous](#) objects are designed to be used by left-handed and right-handed people with equal ease
- Hold a cold drink in the left hand to avoid a cold/wet handshake



Lapel Pins and Name Tags

Wear the [lapel pin](#) and name tag in the location that makes the most sense

- A lapel pin on the left side of a jacket, near the heart
- A name tag on the right side of a shirt, blouse, or blazer



Honda vs. Hyundai

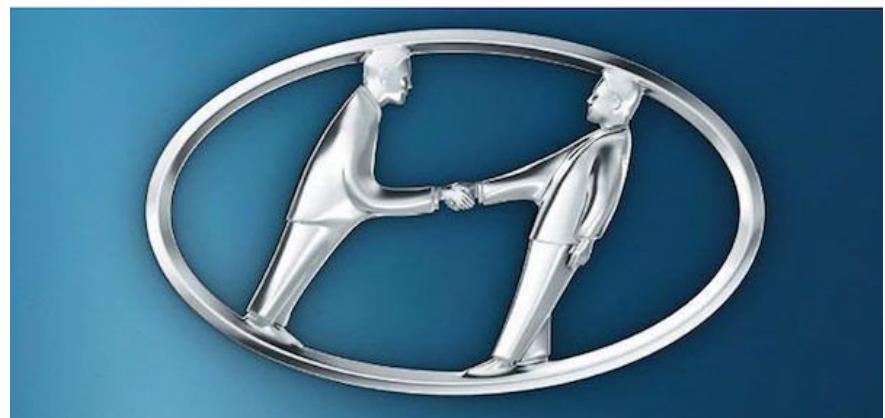


HONDA



HYUNDAI

- Both [Honda](#) and [Hyundai](#) have an H at the beginning of their names
- Unlike the Honda logo, the Hyundai logo is a slanted H, representing two people shaking hands
- Further reading: "[Strategic Intent](#)"



Traditional Greeting in China



- When greeting in China, it is traditional to hold the left hand over the right fist at the chest level
- The right hand, made into a fist, represents the power within, and the holding left hand shows not to use this power

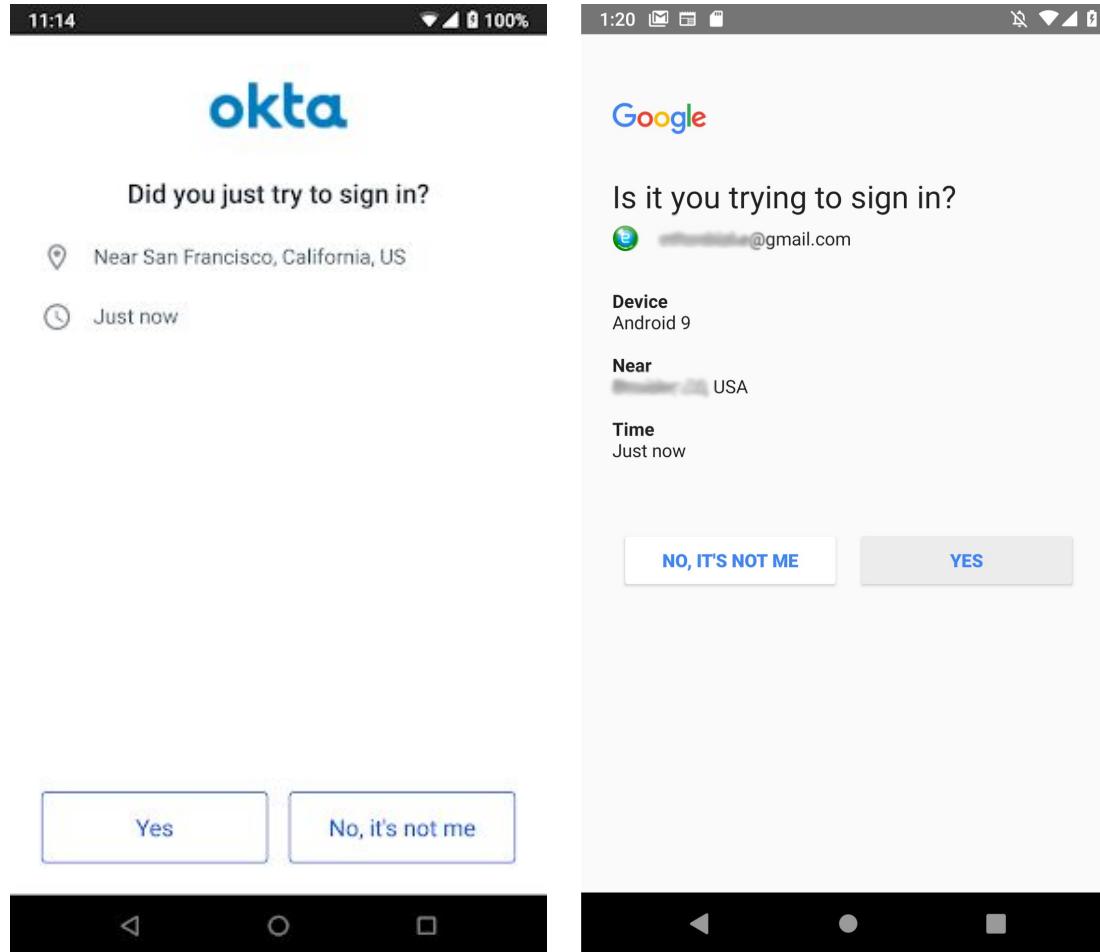
Beyond the handshake: how people greet each other around the world

Customary Greeting in India

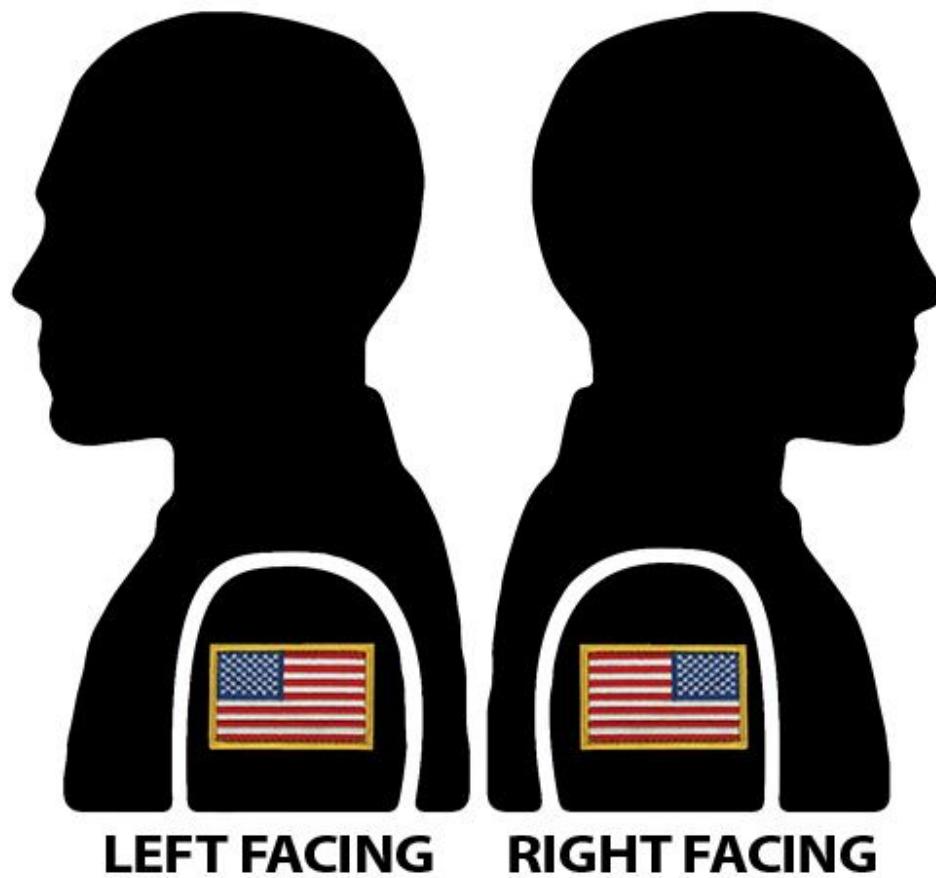


- Namaste via Hindi from Sanskrit *namas* ‘bowing’ and *te* ‘to you’ is a respectful greeting said when giving a namaskar
- Namaskar via Hindi from Sanskrit *namaskāra* (*namas* ‘bowing’ and *kāra* ‘action’) is a traditional Indian greeting or gesture of respect, made by bringing the palms together before the face or chest and bowing

Touchscreen Interfaces



Charging Forward



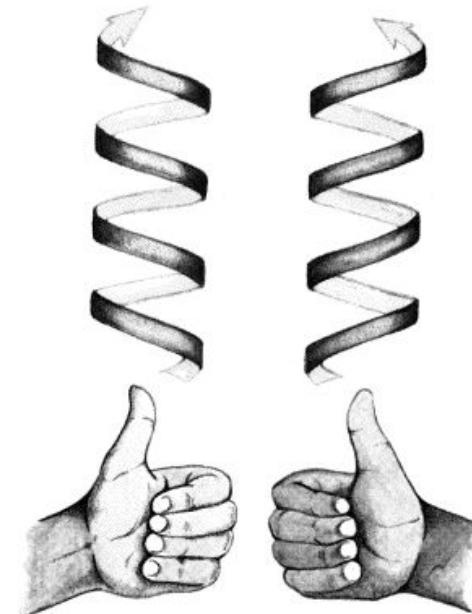
LEFT FACING

RIGHT FACING

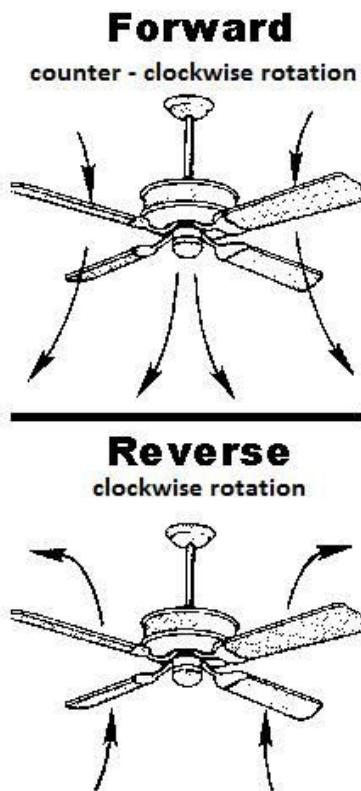
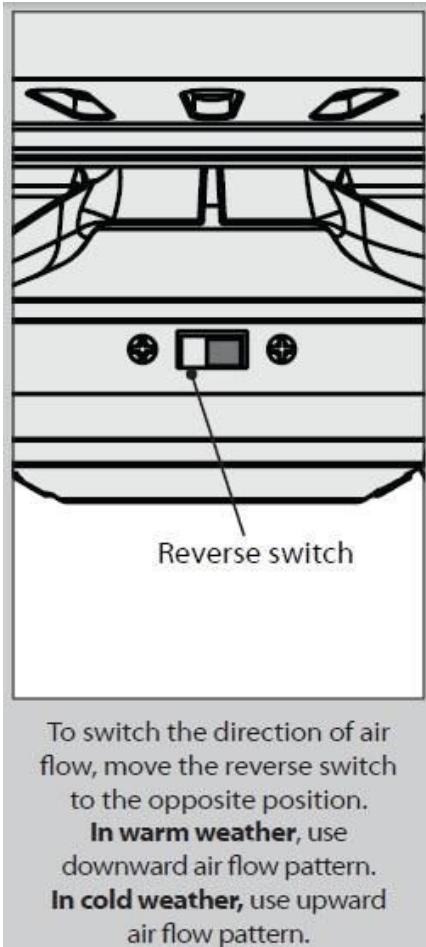
Left- or Right-Handed Stairwells

<https://nerdist.com/theres-a-very-specific-reason-medieval-castles-stairs-were-all-clockwise>

- Most medieval castle stairwells are left-handed, allowing defenders a greater range of movement if they wielded their swords with their right hands
- Those stairwells also diminished the ability of attackers to properly swing their swords, since right-handed fighters would have had to contend with the walls while making their striking motions



Ceiling Fan Direction

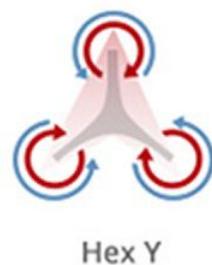
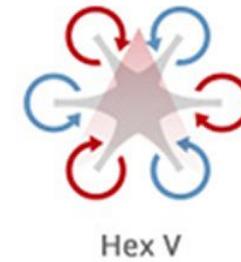
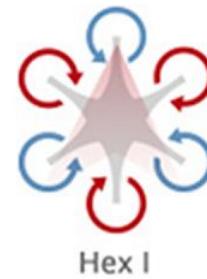


- For cooling effect during the summer, the fan should run in the forward direction (counter-clockwise) to force the room air down, giving the wind chill effect
- During the winter, the fan should run in reverse (clockwise) at a low speed to gently draw the room air up towards the ceiling and force the warm air down and out towards the walls, avoiding the wind chill effect

Drone Propellers (Props)

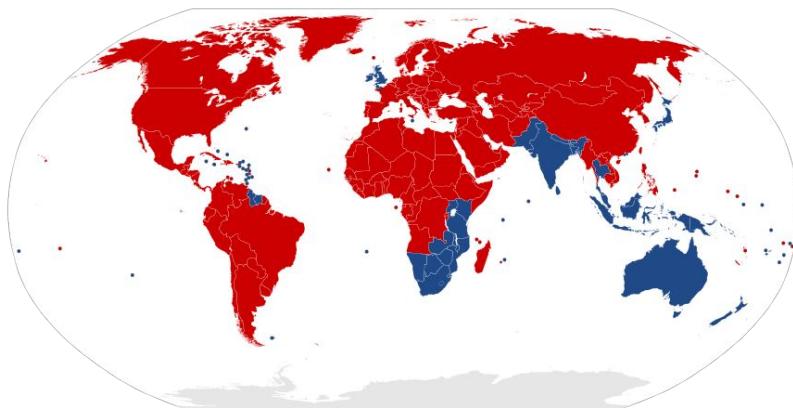
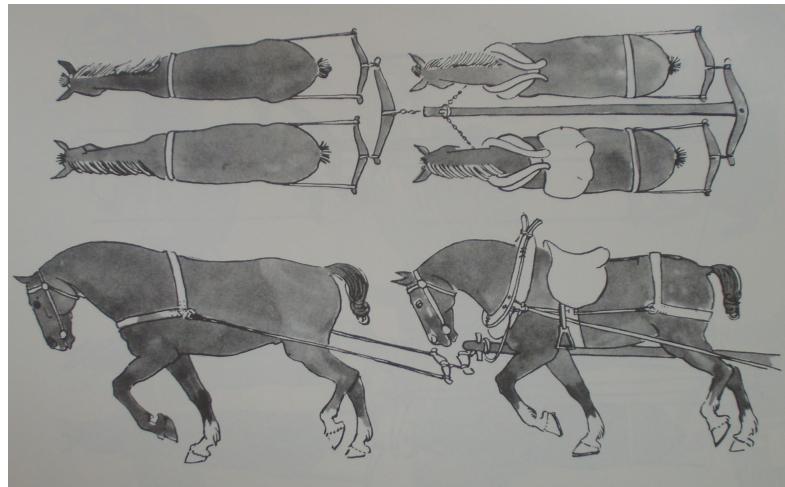
Eduardo Chamorro, Types of Drones

- Drone props rotate either clockwise or counterclockwise, the leading edge is raised above the other side with a concave curve underneath it
- Open-source flight controller firmware such as ArduPilot, Baseflight, Betaflight, Cleanflight, iNAV, LibrePilot, MultiWii, PX4, etc.



Left- or Right-Hand Traffic

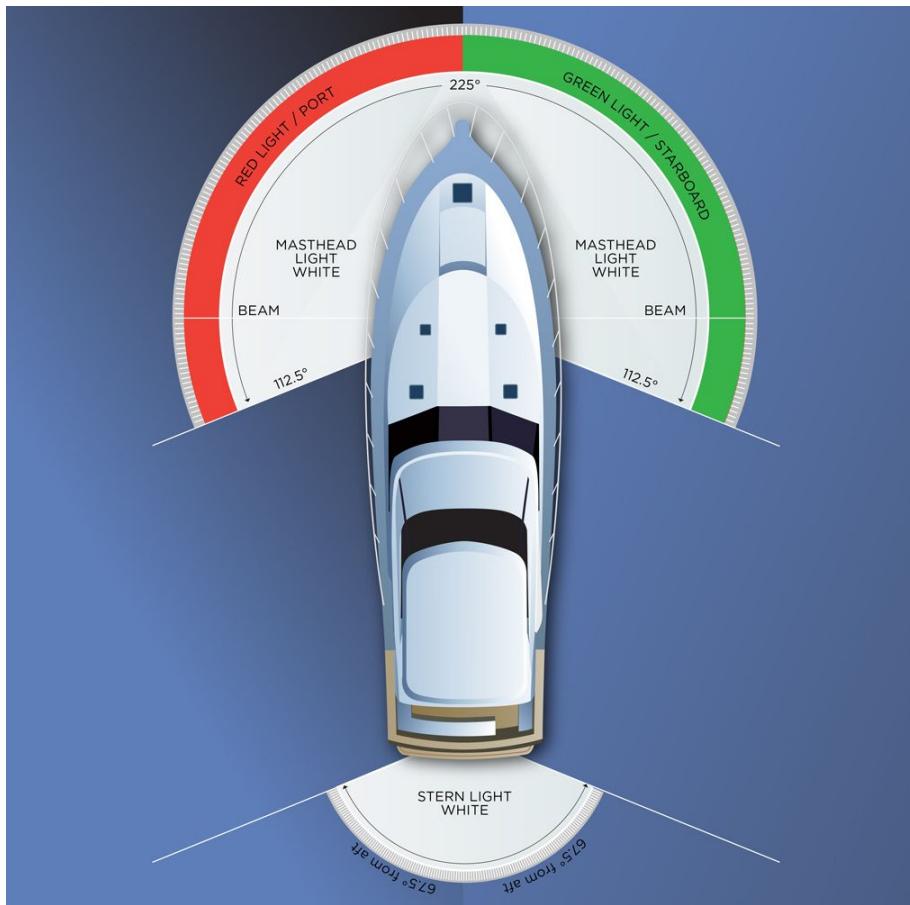
https://en.wikipedia.org/wiki/Left- and_right-hand_traffic



- When horseback was the primary mode of transit, people generally rode on the left side of roads so that their right hand remained free to greet oncoming riders or to attack them with a sword
- With the rise of horse-drawn carriage, drivers would often sit on the left rear horse, so their dominant right hands could more easily control the rest of the team
- It then made sense to drive on the right side of roads so that the driver could keep track of carriages behind
- Countries drive on the left in blue and right in red

Navigation Lights

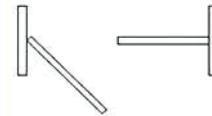
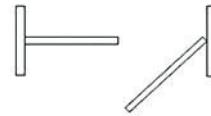
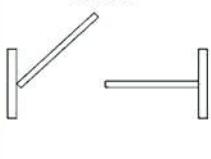
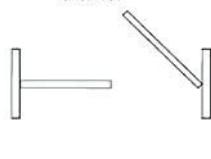
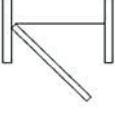
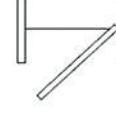
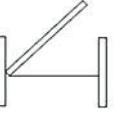
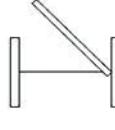
<https://www.seamagazine.com/know-nav-lights>



- Navigation lights on a vessel, aircraft, or spacecraft give information on a craft's position, heading, and status
- Navigation lights are not intended to provide illumination for the craft making the passage, only for other craft to be aware of it
- A craft's starboard side by green and its port side by red
- The term starboard derives from the Old English steorbord, meaning the side on which the ship is steered because more people are right-handed

Door Swing Direction

DOOR SWING SELECTION CHART

Double Door Outswing		Double Door Inswing	
Active/Inactive Outswing	Inactive/Active Outswing	Active/Inactive Inswing	Inactive/Active Inswing
Interior 	Interior 	Interior 	Interior 
Single Door Outswing		Single Door Inswing	
Left Hinged Outswing	Right Hinged Outswing	Left Hinged Inswing	Right Hinged Inswing
Interior 	Interior 	Interior 	Interior 

- The [International Building Code](#) doesn't have a requirement for door swing direction
- The [rule of thumb](#) is to hang interior doors to open into the room, not out into a hallway or other common area
- This is to prevent doors being opened into a traffic path and possibly blocking or bumping into someone going by

Roundabouts

- Although [Carmel, Indiana](#), was home to one of the first electronic automated traffic signals in 1924, it has been building and replacing signalized intersections with [roundabouts](#) since [1996](#) (at River Road and Main Street)
- Roundabouts work because of their safety record, pollution and cost reduction, traffic capacity increase, aesthetic landscaping, and ability to make it easier for pedestrians and bicyclists to navigate



Droid and Android

A humanoid robot is designed to look and act like a human, e.g., a droid such as R2-D2 and C-3PO, or an android that is built to aesthetically resemble humans such as Lieutenant Commander Data



The Night Watch, 1642 and 1715



- The Night Watch, a 1642 painting by Rembrandt van Rijn 1606—1669, was trimmed on all four sides in 1715 to fit the painting between two columns
- This alteration resulted in the loss of two characters on the left side of the painting, the balustrade, and the edge of the step that were key visual tools used by Rembrandt to give the painting a forward motion

Las Meninas, 1656



- *Las Meninas* (*The Ladies-in-waiting*) by Diego Velázquez 1599—1669 has been one of the most analyzed works in painting because of its complex composition of the figures depicted
- The young Infanta Margaret Theresa of Spain is surrounded by her entourage including maids of honor, chaperone, bodyguard, two dwarfs, a dog, and the queen's chamberlain at the door in the background
- Velázquez portrays himself working at a large canvas
- In the background, there is a mirror that reflects the upper bodies of King Philip IV and Queen Mariana of Austria

Iterative Design and Makeover

- [Iterative design](#) is based on a cyclic process of prototyping, testing, analyzing, and refining a product or process
- In Greek mythology, the [Sirens](#) lured nearby sailors with their enchanting music and singing voices to shipwreck on the rocky coast of their island
- The Sirens had transformed from birds with women's heads to [mermaids](#)
- Since 2011, the [Starbucks Siren logo](#) became more symmetrical, and even got friendly eyes, before the [Lippincott](#) designers reverted back to an asymmetrical design with a bit more shadow on the right side of the face having a mythical, mysterious, alluring quality

